Over grazing and improper grazing techniques adjacent to Cascade Reservoir (right) have been replaced with proper grazing and reestablishment of riparian vegetation (left).

Compendium of Best Management Practices To Control Polluted Runoff

A SOURCE BOOK

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Urban Activities/Storm Water Runoff

This sector includes a wide range of activities that can contribute pollutants to streams, lakes, and ground water via storm water runoff. Land development contributes to the problem through the creation of impervious surfaces such as city streets, driveways, parking lots, and sidewalks. Impervious areas act as collectors for pollutants from concentrated human activities. Pollutants can fall out of the sky during dryfall or they may arrive in rain or snow as wetfall. Pollutants can also be blown in from adjacent pervious areas. Pollutants land on street or other impervious surfaces where they often stay in curbs, cracks and other areas until the next rainstorm when they are washed off the surface and into the storm drain system and ultimately to receiving streams. Activities that can contribute pollutants include development activities; activities associated with existing residential, commercial and industrial sources; illicit discharges, and illegal dumping.

The major pollutants found in runoff from urban areas include sediment, nutrients, oxygen-demanding substances, road salts, heavy metals, petroleum hydrocarbons, pathogenic bacteria, and viruses. Suspended sediments constitute the largest mass of pollutant loadings to receiving waters from urban areas. Construction is a major source of sediment erosion. Nutrient and bacterial sources of contamination include fertilizers, pet wastes, leaves, grass clippings, and faulty septic tanks. Petroleum hydrocarbons result mostly from automobile sources.

In addition to water quality impacts, land development impacts the hydrology and geomorphology of the receiving water, and affects aquatic and riparian habitats. Development results in impervious surfaces that eliminate the natural retention provided by vegetation and soil in undeveloped areas. Increasing impervious surfaces increases the quantity of water delivered to a waterbody during storms. This results in increased runoff with more rapid peak discharges. Changes in the volume and timing of runoff can result in stream widening, erosion, decreased channel stability, embeddedness, and decreased substrate quality.

For the purposes of this discussion, urban management practices are organized into the following groups: public education and involvement, municipal operations, illicit discharges, industrial activities, construction sites, and new development. On-site wastewater disposal systems or septic systems are also discussed in this section. While not necessarily an urban source, the use of septic systems on the urban fringe and in rural subdivisions can act as a source of nitrogen, phosphorus, organic matter, and bacterial and viral pathogens.

Public Education and Involvement

Everyday activities have the potential to contribute pollutants to runoff. Some of the major sources include households, garden and lawn care activities, turf grass management, diesel and gasoline vehicles, illegal discharges to urban runoff conveyances, commercial activities, and pets and domesticated animals. Everyday household activities generate numerous pollutants that may affect water quality. Common household pollutants include paints, solvents, lawn and garden care products, detergents and cleansers, and automotive products such as antifreeze and oil.

These pollutants are typically introduced into the environment due to ignorance on the part of the user or the lack of proper disposal options. Storm drains are commonly mistaken for treatment systems, and significant loadings to waterbodies result from this misconception. Other wastes and chemicals are dumped directly onto the ground.

The practices that address these sources of pollutants can result in behavioral changes. Such activities include public education, promotion of alternative and public transportation, proper management of maintained landscapes, pollution prevention, training and urban runoff control plans for commercial sources. Public education increases awareness of problems and available solutions.

Public involvement will ensure broader public understanding and support, provide a broader base of expertise, and provide additional resources to the program through volunteer activities. Opportunities for members of the public to participate in program development and implementation include serving as citizen representatives on a local storm water management panel, attending public hearings, working as citizen volunteers to educate other individuals about the program, assisting in program coordination with other pre-existing programs, and participating in volunteer monitoring efforts.

Municipal Operations

Municipal operations can be addressed through proper maintenance activities, maintenance schedules, and long-term inspection procedures; controls for reducing or eliminating the discharge of pollutants from areas such as roads and parking lots, maintenance and storage yards, and waste transfer stations; and procedures for the proper disposal of waste removed by maintenance activities. The construction and operation of roads is discussed in greater detail in Section 7.

Illicit Discharges

Significant pollutants can enter surface waters and tributaries via illegal discharges into storm drains. The public assumes that storm drains discharge into sanitary sewers, and materials are dumped into storm drains under the assumption that treatment will occur at the sewage treatment plant. Sources of illicit discharges include such things as car wash wastewaters, improper oil disposal, radiator flushing disposal, sump pump discharges, and improper disposal of household chemicals.

Another source of illicit discharges is possible illicit connections to storm drain systems (e.g. wastewater piping either mistakenly or deliberately connected to storm drains). Types of illicit discharges include such things as sanitary wastewater, effluent from septic tanks, and laundry wastewaters. Sanitary sewer connections can result in fecal coliform bacteria entering the storm sewer system, and floor drains can contribute other non-storm water discharges.

Illicit discharges are addressed through regulation and education. Public education programs, such as storm drain stenciling, and identification of illicit discharges can be effective tools to reduce pollutant loadings. A sanitary surveys is also a useful method to help managers identify the presence and entry point(s) of illicit discharges or other sources of pollutants to storm sewer systems.

Industrial Activities

Activities that take place at industrial facilities, such as material handling and storage, are often exposed to storm water. The runoff from these activities discharges industrial pollutants into nearby storm sewer systems and waterbodies. This may adversely impact water quality.

There are good housekeeping practices, structural controls, site-specific and activity-specific source control practices that can be used to control potential pollutants from industrial activities. The site-specific controls include flow diversion practices, exposure minimization practices, mitigative practices, and a variety of prevention practices.

Construction Sites

Construction site practices control erosion and sediment discharge, as well as other pollutants from paving operations; handling and storage of various materials; spills; and handling wastes such as pesticides, oil and grease, concrete truck washout, construction chemicals, construction debris, solvents, paints, sanding dusts, and fertilizers.

Opportunities for achieving pollutant reductions can be incorporated into the site plan review and land use planning processes. An erosion and sediment control ordinance can be implemented through the site planning process and verified through the review process.

Construction site management practices can be categorized as erosion control practices, which prevent or minimize erosion; sediment control practices, which attempt to capture soil released through erosion; and source controls. Erosion control includes various practices designed to keep water from coming in contact with bare soil or controlling its velocity if it does. Sediment trapping is used for sediment control. The two basic types of sediment trapping techniques in use are sediment barriers and settling ponds. Source controls are used in the management of other construction site pollutants.

New Development

Structural and non-structural practices are available to address post-construction development impacts. Structural controls include infiltration devices, detention and retention basins, vegetated swales, water quality inlets, screens and filters, channel stabilization, riparian habitat enhancement efforts, and wetland restoration projects.

Non-structural practices are preventative actions that involve management and source controls such as:

- Policies and ordinances that provide requirements and standards to direct growth to identified areas, protect sensitive areas such as wetlands and riparian areas, maintain and/or increase open space, provide buffers along sensitive water bodies, minimize impervious surfaces, and minimize disturbance of soils and vegetation;
- Policies or ordinances that encourage infill development in higher density urban areas and areas with existing infrastructure; and
- Practices such as minimization of percent impervious area after development and minimization of directly connected impervious areas.

Storm water management can be achieved by relying on existing land development requirements, strengthening or developing new storm water codes and ordinances, and using the site plan review process to ensure that appropriate storm water codes and ordinances are implemented. Land use planning is an additional process that precedes (but does not replace) the site plan review process. The planning process typically involves the setting of land use goals and objectives for various parts of a municipality into a plan document or onto a plan map. Water quality can be addressed by incorporation of policies regarding storm water quality into the land use.

Septic Systems

On-site sewage disposal systems or septic systems can act as sources of nitrogen, phosphorus, organic matter, and bacterial and viral pathogens either because of inadequate design, inappropriate installation, neglectful operation, or exhausted lifetime. The greatest design inadequacy associated with conventional septic systems is the failure to remove nitrogen effectively.

Inappropriate installation often involves improper siting, including locating in areas with inadequate separation distances to ground water, inadequate absorption areas, fractured bedrock, sandy soils, inadequate soil permeability, or other conditions that prevent adequate treatment of wastewater if not accounted for. Inappropriate installation can also include smearing of trench bottoms during construction, compaction of the soil bed by heavy equipment, and improperly performed percolation tests.

Hydraulic overloading is responsible for the majority of system failures related to system operation. Regular inspection and maintenance are necessary and often do not occur. Finally, conventional septic systems are designed to operate over specified periods of time. At the end of the expected life span, replacement is generally necessary. Homeowners may be unaware of this issue or unable to afford a replacement.

One good management practice for septic systems is to place it away from an unsuitable area. Where placement in unsuitable areas is not practicable, then alternative systems should be considered or systems should be designed or sited at a density so as not to adversely affect surface waters or ground water. Protective setbacks from surface waters, wetlands, and floodplains for conventional as well as alternative systems should be established. Protective separation distances between system components and ground water should also be established.

In addition to soil criteria, setbacks, and separation distances, management and maintenance requirements should be established. Local jurisdictions can establish and implement policies and systems to ensure that existing systems are operated and maintained. Management options for maintenance include maintaining the system via contract, requiring operating permits, using private management systems, and passing local ordinances.

Policies can be established that require a system be repaired, replaced, or modified when it fails, threatens, or impairs surface waters. Systems should be inspected at a frequency adequate to ascertain whether they are failing. One way to reduce the possibility of failed systems is to require scheduled pumpouts and regular maintenance. Inspections upon resale or change of ownership of properties are also a cost-effective solution to ensure that systems are operating properly and meet current standards necessary to protect surface waters.

TABLE 5. Urban/Storm Water Practices

PRACTICE *(ADDITIONAL SOURCES OF INFORMATION)*	TARGETED POLLUTANTS B bacteria F floatables N nutrients DO dissolved oxygen H hydrocarbons TP temperature T toxics S sediment	MECHANISM											
		SOURCE CONTROL							TREATMENT CONTROL				
		Managerial/ Operational	Good Housekeeping	Collection/ Conveyance	Containment	Reduction/ Elimination	Protection	Stabilization	Biological Treatment	Chemical Treatment	Filtration	Infiltration	Sedimentation
PUBLIC EDUCATION													
Proper Disposal of Household Hazardous Wastes	T	✓											
Pet Waste Management	B, N		✓										
Pollution Prevention for Business	All	✓											
Educational Programs for School Age Children	All	✓											
Storm Drain Stenciling	All					✓							
PUBLIC INVOLVEMENT													
Community Cleanups	F					✓							
Adopt-A-Stream Programs	All					✓							
Community Hotlines	All					✓							
ILLICIT DISCHARGE DETECTION													
Identify Illicit Connections	All					✓							
Repair Leaking Sewer Lines	B, N					✓							
Hookup Failing Septic Systems to Sanitary Sewer	B, N					✓							
Prohibit Illegal Dumping	All	✓											
Dry Weather Outfall Screening	All	✓											
CONSTRUCTION SITE CONTROLS													
Sediment Control	S												✓

continued

PRACTICE *(ADDITIONAL SOURCES OF INFORMATION)*	**TARGETED POLLUTANTS** B bacteria F floatables N nutrients DO dissolved oxygen H hydrocarbons TP temperature T toxics S sediment	**MECHANISM**											
		SOURCE CONTROL							**TREATMENT CONTROL**				
		Managerial/ Operational	Good Housekeeping	Collection/ Conveyance	Containment	Reduction/ Elimination	Protection	Stabilization	Biological Treatment	Chemical Treatment	Filtration	Infiltration	Sedimentation
Construction Site Controls (continued)													
Construction Entrance and Roads	S							✓					
Permanent Stabilization	S							✓					
Runoff Controls	S			✓									
Storm Drain Inlet Protection	S						✓						
Source Controls	N, H, T, S	All											
INDUSTRIAL CONTROLS													
Vehicle and Equipment Fueling	H	✓											
Vehicle and Equipment Maintenance and Repair	N, H, T	✓											
Outdoor Loading/ Unloading	All	✓											
Outdoor Process Equipment Operations	All	✓											
Outdoor Storage	All	✓											
Waste Handling and Disposal	All		✓										
Building and Grounds Maintenance	N, T, S		✓										
Spill Prevention and Control	All	✓											
NONSTRUCTURAL CONSTRUCTION CONTROLS													
Site Plan Review Procedures	S	✓											

continued

PRACTICE *(ADDITIONAL SOURCES OF INFORMATION)*	TARGETED POLLUTANTS B bacteria F floatables N nutrients DO dissolved oxygen H hydrocarbons TP temperature T toxics S sediment	MECHANISM											
		SOURCE CONTROL							TREATMENT CONTROL				
		Managerial/ Operational	Good Housekeeping	Collection/ Conveyance	Containment	Reduction/ Elimination	Protection	Stabilization	Biological Treatment	Chemical Treatment	Filtration	Infiltration	Sedimentation
Non-Structural Construction Controls (continued)													
Contractor Education	S	✓											
STRUCTURAL CONTROLS FOR DEVELOPMENT See *State of Idaho Catalog of Stormwater Best Management Practices for Idaho Cities and Counties* (DEQ, 2001)													
NONSTRUCTURAL DEVELOPMENT CONTROLS													
Buffer Zones	B, N, S					✓	✓						
Open Space Design	B, N, S					✓	✓						
Comprehensive Planning/ Zoning	All	✓											
Integrative Ordinances	All	✓											
Site-Based Local Controls	B, N, S	✓											
Low Impact Development Techniques	B, N, S					✓	✓						
MUNICIPAL OPERATIONS													
Parking Lot Cleaning	B, N, H, T, S		✓										
Street Sweeping	B, N, H, T, S		✓										
Storm Drain System O&M	B, N, H, T, S		✓										
Vehicle Maintenance Practices	H, T	✓											
Employee Training	All	✓											
Materials Management	All	✓											
Snow Removal/Deicing Practices	N, S		✓										
Storm Water System Retrofitting	N, S								✓		✓		✓
Vegetation Management	B, N, S	✓											

continued

PRACTICE *(ADDITIONAL SOURCES OF INFORMATION)*	TARGETED POLLUTANTS B bacteria F floatables N nutrients DO dissolved oxygen H hydrocarbons TP temperature T toxics S sediment	MECHANISM											
		SOURCE CONTROL							TREATMENT CONTROL				
		Managerial/ Operational	Good Housekeeping	Collection/ Conveyance	Containment	Reduction/ Elimination	Protection	Stabilization	Biological Treatment	Chemical Treatment	Filtration	Infiltration	Sedimentation
Municipal Operations (continued)													
Riparian Area Management	B, N, S, TP						✓						
Revegetation	B, N, S, TP						✓	✓					
Streambank Stabilization	N, S							✓					
Urban Forestry	N, S, TP					✓							
ON-SITE DISPOSAL SYSTEMS													
Siting Criteria	B, N	✓											
Design and Construction	B, N	✓							✓		✓	✓	
Operation and Maintenance	B, N	✓											
Alternative Systems	B, N								✓		✓	✓	

URBAN STORM WATER SECTOR BMPS

There are a number of new stream channel restoration projects along Paradise Creek within the City of Moscow. Where previously in the mid 1900s the stream channel had been straightened, deepened, and lined with rip rap to allow for development, a large and diverse group of stakeholders led by the Palouse-Clearwater Environmental Institute are now conducting a superb effort to recreate a meandering channel and flood plain.

◂ *The work being accomplished as shown in this photo will reduce the amount of sediment entering the creek from urban storm water runoff and alleviate the erosion that was occurring along the streambanks. This work combined with recreation of flood plains and reestablishment of native vegetation will return this stream segment to a fish friendly environment.*

▶ *The wetland retention pond shown here will serve the multiple purposes of filtering storm water prior to discharge to Paradise Creek, creation of good habitat for urban wildlife and creation of an aesthetically pleasing park-like wildlife study area for local students. Each of the blue plastic sleeves protects a newly planted native woody or herbaceous species plant.*

◄ *In order to ensure that urban area BMPs are fostered, maintained and protected BMPs such as public involvement and public education are essential. The events shown in this photo and the photo on the following page took place several months after the heavy construction seen on page 51.*

▶ *Over 200 school children planted trees and shrubs at the second annual Paradise Creek Watershed Festival. The October 2002 festival was part of the local match for a Clean Water Act section 319 project designed to construct a functional flood-plain, recreate meanders, stabilize stream banks, and plant a native riparian vegetation buffer along Paradise Creek in northern Idaho.*

Transportation Activities

Categories of activities in the transportation sector include road construction, operation and maintenance, and post-construction runoff. Erosion during and after construction of roads, highways, and bridges can contribute large amounts of sediment and silt to runoff waters, which can deteriorate water quality and lead to fish kills and other ecological problems. Heavy metals, oils, other toxic substances, and debris from construction traffic and spillage can be absorbed by soil at construction sites and carried with runoff water. Pesticides and fertilizers used along roadway rights-of-way and adjoining land can pollute surface waters and ground water when they filter into the soil or are blown from the area where they are applied. Runoff controls are essential to preventing polluted runoff from roads, highways, and bridges from reaching surface waters.

Road Construction

Practices are implemented during site development and land disturbing activities for new, relocated, and reconstructed roads and highways in order to reduce the generation of runoff and to mitigate the impacts of urban runoff and associated pollutants from such activities. The best time to address control of pollution from roads and highways is during the initial planning and design phase. New roads and highways should be located with consideration of natural drainage patterns and planned to avoid encroachment on surface waters and wet areas. Adequate setback distances near wetlands, waterbodies, and riparian areas should be provided to ensure protection from encroachment in the vicinity of these areas. Locations requiring excessive cut and fill; subject to subsidence; or with sinkholes, landslides, rock outcroppings, and highly erodible soils should be avoided.

Construction site management is the application of erosion and sediment control during the life of the construction phase of a project. Construction site management not only covers the actual construction area, but also applies to construction support areas such as staging areas, materials source or stockpiling areas, and construction-related areas, such as batch plants located off site.

Temporary erosion and sediment control practices are short-term practices used to reduce or eliminate erosion and are designed and installed to keep as much sediment on site as possible. These practices are used when areas are disturbed due to construction, or when an emergency such as a slide or flood has occurred. A temporary erosion and sediment control practice is normally used for one to six months, or until a more permanent practice is put into place.

Post-Construction Runoff Controls

Permanent erosion and sediment control practices and storm water runoff controls are long-term practices, designed for the life of a project. Permanent controls are designed to reduce or control erosion and storm water runoff and are put in place during construction with beneficial results extending over a period of years. Examples of permanent storm water controls are vegetated filter strips, grassed swales, pond systems, infiltration systems, constructed urban runoff wetlands, and energy dissipaters and velocity controls.

Operation and Maintenance

Substantial amounts of eroded material and other pollutants can be generated by the operation and maintenance of roads, highways, and bridges, and from sparsely vegetated areas, cracked pavement, potholes, and poorly operating urban runoff control structures. Good practices related to these activities consist of using standard operating procedures for nutrient and pesticide management, minimizing road salt use, and following maintenance guidelines (e.g., capture and contain paint chips and other particulates from bridge maintenance operations, resurfacing, and pothole repairs).

TABLE 6. Transportation Practices

PRACTICE *(ADDITIONAL SOURCES OF INFORMATION)*	**TARGETED POLLUTANTS** B bacteria F floatables N nutrients DO dissolved oxygen H hydrocarbons TP temperature T toxics S sediment	**MECHANISM**											
		SOURCE CONTROL							**TREATMENT CONTROL**				
		Managerial/ Operational	Good Housekeeping	Collection/ Conveyance	Containment	Reduction/ Elimination	Protection	Stabilization	Biological Treatment	Chemical Treatment	Filtration	Infiltration	Sedimentation
DESIGN PRACTICES													
Avoid Sensitive Areas	S	✓					✓						
Setbacks	S						✓						
Downstream Effects Evaluation	Not Applicable	✓											
Preservation of Existing Vegetation	N, S	✓					✓						
CONSTRUCTION PRACTICES													
Construction Site Management	F, H, S, T	✓											
Dust Control	S					✓							
Preservation of Existing Vegetation	N, S						✓						
Scheduling/Sequencing	S	✓											
Staging and Materials Site Management	F, S	✓											
Temporary Roads	S							✓					
Construction Entrances	S							✓					
EROSION AND SEDIMENT CONTROL													
Check Dams	S							✓					
Coffer Dams	S			✓									
Dikes and Berms	S			✓									
Diversion Channels	S			✓									
Inlet Protection	S						✓						
Outlet Protection	S						✓						

continued

PRACTICE *(ADDITIONAL SOURCES OF INFORMATION)*	TARGETED POLLUTANTS B bacteria F floatables N nutrients DO dissolved oxygen H hydrocarbons TP temperature T toxics S sediment	MECHANISM											
		SOURCE CONTROL							TREATMENT CONTROL				
		Managerial/ Operational	Good Housekeeping	Collection/ Conveyance	Containment	Reduction/ Elimination	Protection	Stabilization	Biological Treatment	Chemical Treatment	Filtration	Infiltration	Sedimentation
Erosion and Sediment Control (continued)													
Perimeter Protection	S						✓						
Sediment Trap Basins	S			✓									✓
Slope Drains	S			✓									
Stream Crossing	S						✓						
Soil Stabilization	S							✓					
Vegetation/Seeding	S						✓	✓					
Vegetation/Planting	S						✓	✓					
POST-CONSTRUCTION CONTROLS													
Check Dams	S							✓					
Flexible Liners	S				✓								
Rigid Channel Liner	S				✓								
Dikes and Berms	S				✓								
Geosynthetics	S							✓					
Inlet Protection	S						✓						
Outlet Protection	S						✓						
Interceptor Trench	S			✓									
Structural Treatment Practices	B, N, H, T, S								✓		✓	✓	✓
OPERATION AND MAINTENTANCE PRACTICES													
Litter and Debris Removal	F		✓										
Vegetation Control	S	✓											
Snow Removal and De-icing	N, S	✓											

continued

PRACTICE *(ADDITIONAL SOURCES OF INFORMATION)*	**TARGETED POLLUTANTS** B bacteria F floatables N nutrients DO dissolved oxygen H hydrocarbons TP temperature T toxics S sediment	**MECHANISM**													
		SOURCE CONTROL							**TREATMENT CONTROL**						
		Managerial/ Operational	Good Housekeeping	Collection/ Conveyance	Containment	Reduction/ Elimination	Protection	Stabilization	Biological Treatment	Chemical Treatment	Filtration	Infiltration	Sedimentation
Operation and Maintenance Practices (continued)															
Sweeping and Vacuuming	B, N, H, T, S		✓										
Maintenance Facility Housekeeping Practices	B, N, H, T, S		✓										
Illicit Connection Detection and Removal	B, N, H, T, S				✓								
Illegal Discharge Control	B, N, H, T, S	✓			✓								
Storm Drain Inspection and Maintenance	B, N, H, T, S	✓											

The *Paradise Creek TMDL Implementation Project* is one of Idaho's largest and most successful nonpoint source pollution abatement projects. This project is overseen by the Palouse-Clearwater Environmental Institute and is funded in part through Idaho DEQ's NPS/319 grant program. Paradise Creek drains 35 square miles including 55 stream segments. Forty-nine segments originate in agricultural fields north of Moscow, Idaho and the balance originating within city limits. The upper Paradise Creek Watershed consists of wind derived silt and clay locally referred to as the Palouse Country. When Palouse Country fields are tilled this fine-grained material becomes extremely vulnerable to erosion.

▶ *This segment of Paradise Creek (concealed by vegetation along the left side) runs along the urban/rural boundary just north of Moscow, Idaho. The hay field (right side of photo) used to be cultivated right up to the creek bank resulting in considerable erosion and sedimentation of Paradise Creek. Now, through cooperation from the landowner, this permanent zone of thick grass prevents erosion of sediment and nutrients when the hay field is cultivated.*

◂ *The BMP shown here known as a gully plug is a small constructed retention basin with a riser and an underdrain pipe system that discharges several hundred feet down gradient where the terrain is nearly flat. A frequent application of this BMP allows maximum acreage to be cultivated with a minimum of erosion.*

▶ *In the upper Paradise Creek Watershed not far down hill from the gully plug previously described, these men are walking up a watercourse that is permanently covered with grass. Used as an alternative to gully plugs this vegetative strip BMP displaces cash crops but offers a good driving surface for farm equipment while preventing erosion. Vegetative strips are used in more pronounced waterways where gully plugs would not be adequate. Note that the hills on both sides have been prepared using no-till techniques for crops.*

Marinas and Recreational Boating

Marinas may pose a threat to the health of aquatic systems and may pose other environmental hazards when these facilities are poorly planned or managed. Ensuring the best possible siting for marinas, as well as the best available design and construction practices and appropriate operation and maintenance practices, can greatly reduce polluted runoff pollution from marinas.

Because marinas are located right at the water's edge, there is often no buffering of the release of pollutants to waterways. Adverse environmental impacts may result from the following situations of pollution associated with marinas and recreational boating:

- Poorly flushed waterways where dissolved oxygen deficiencies exist;
- Pollutants discharged from boats;
- Pollutants transported in storm water runoff from parking lots, roofs, and other impervious surfaces;
- The physical alteration or destruction of wetlands and of shellfish and other bottom communities during the construction of marinas, ramps, and related facilities; and
- Pollutants generated from boat maintenance activities on land and in the water.

A marina can have a significant impact on the concentrations of pollutants in the water, sediment, and tissues of organisms within the marina itself. Although sources of pollutants outside the marina are part of the problem, marina design, operation, and location appear to play crucial roles in determining whether local water quality is impacted. Marina construction may alter the type of habitat found at the site. Some of the impacts that can be associated with marina and boating activities include toxicity in the water column from discharges from boats or other sources, spills, or storm water runoff; fecal coliform bacteria in areas with high boat densities and low hydrologic flushing; habitat destruction and increased turbidity from boat operation and dredging; and shoaling and shoreline erosion from the physical transport of sediment due to waves and/or currents.

Marinas Siting and Design

In selecting a marina site and developing a design, consideration of the need for the efficient flushing of marina waters should be a prime factor along with safety and vessel protection. For example, sites located on open water or at the mouths of creeks and tributaries usually have higher flushing rates. These sites are generally preferable to sites located in coves or toward the heads of creeks and tributaries, locations that tend to have lower flushing rates.

Assessments of water quality conditions and habitat prior to marina development are another practice for protecting water quality. The first step in a marina water quality assessment should be the evaluation and characterization of existing water quality conditions. Before an analysis of the potential impacts of future development is made, it should be determined whether current water quality is acceptable, marginal, or substandard. The second step in a marina water quality assessment is to set design standards in terms of water quality.

A habitat assessment is a practice used to characterize a proposed project site and is done to achieve compatibility between development and resources. A site's physical properties are assessed. To minimize potential impacts, available habitat and seasonal use of the site by benthos, macroinvertebrates, and fish should be evaluated. Once these data are assembled, it becomes possible to identify environmental risks associated with development of the site.

Shoreline Stabilization

Activities associated with a marina and boating operations can cause shoreline erosion. Planting vegetation can stabilize shorelines. This approach has shown the greatest success in low-wave-energy areas where underlying soil types provide the stability required for plants and where conditions are amenable for sustaining of plant growth. Under suitable conditions, an important advantage of vegetation is its relatively low initial cost. Identification of the cause of the erosion problem is essential for selecting the appropriate technique to remedy the problem.

Some structural methods to stabilize shorelines and navigation channels are bulkheads, jetties, and breakwaters. They are designed to dissipate incoming wave energy. While structures can provide shoreline protection, unintended consequences may include accelerated scouring in front of the structure, and increased erosion of unprotected downstream shorelines. Gabions, riprap, and sloping revetments dissipate incoming wave energy most effectively and result in the least scouring. Bulkheads are appropriate in some circumstances, but where alternatives are appropriate the alternatives should be used first.

Storm Water Runoff

Source controls and structural facilities can be used to control storm water runoff from a marina. Structural facilities include sand filters, ponds, wetlands, infiltration basins and trenches, chemical and filtration treatment systems, vegetated filter strips and grassed swales, porous pavement, oil-grit separators, catch basins, absorbents in drain inlets, holding tanks, and swirl concentrators. Source controls are applied to activities that occur on site and reduce or control the potential for pollutants to be discharged. Leak and spill prevention is one example.

Sewage Facility Management

Management systems for controlling pollutants from sewage facilities include fixed-point systems, portable systems, and dedicated slipside systems. Fixed-point collection systems include one or more centrally located sewage pumpout stations. Portable systems are similar to fixed-point systems and in some situations may be used in their place at a fueling dock. The portable unit includes a pump and a small storage tank connected to the deck fitting on the vessel, and wastewater is pumped from the vessel's holding tank to the pumping unit's storage tank. Dedicated slipside systems provide continuous wastewater collection at a slip. Marina operators should also post ample signs prohibiting the discharge of sanitary waste from boats into the waters of the state, including the marina basin, and also explaining the availability of pumpout services and public restroom facilities.

Sewage facility maintenance can be addressed through maintenance contracts with contractors competent in the repair and servicing of pumpout facilities, a regular inspection schedule, adding language to slip leasing agreements mandating the use of pumpout facilities and specifying penalties for failure to comply, and placing dye tablets in holding tanks to discourage illegal disposal.

Waste Management

Solid waste can be controlled at marinas by designating work areas for boat repair and maintenance, regularly maintaining these areas, providing proper disposal facilities, and facilities for recycling appropriate materials. Establishing fish cleaning areas and cleaning rules, educating boaters, and implementing fish composting where appropriate can also control fish waste. Practices to control liquids include building curbs, berms, or other barriers around areas used for the storage of liquid material to contain spills; separating containers for the disposal of waste liquids; and directing marina patrons as to the proper disposal of all liquid materials through the use of signs, mailings, and other means.

Fueling Operations

Potential pollutants from fueling stations can be prevented by locating and designing fueling stations so that spills can be contained in a limited area, having a spill contingency plan, and designing fueling stations with spill containment equipment.

Fuel and oil are commonly released into surface waters during fueling operations through the fuel tank air vent, during bilge pumping, and from spills directly into surface waters and into boats during fueling. Oil and grease from the operation and maintenance of inboard engines are a source of petroleum in bilges. Petroleum control can be achieved through the use of automatic shut-off nozzles and fuel/air separators on air vents or tank stems of inboard fuel tanks to reduce the amount of fuel spilled into surface waters during boat fueling. The use of oil-absorbing materials in the bilge areas of all boats with inboard engines can also be promoted.

Boat Operations

Management practices that affect boat operations include excluding motorized vessels from areas that contain important shallow-water habitat and establishing and enforcing no-wake zones to decrease turbidity. Boat cleaning practices to protect water quality include washing the boat hull above the waterline by hand and using detergents and cleaning compounds that are phosphate-free and biodegradable.

The best method of preventing pollution from marinas and boating activities is to educate the public about the causes and effects of pollution and methods to prevent it. Creating a public education program should involve user groups and the community in all phases of program development and implementation. The program should be suited to a specific area and should use creative promotional material to spread its message. Examples of practices include signage, recycling and trash reduction programs, pamphlets or flyers, newsletters, inserts in billing, and meetings and presentations.

TABLE 7. Marina and Recreational Boating Practices

PRACTICE *(ADDITIONAL SOURCES OF INFORMATION)*	**TARGETED POLLUTANTS** B bacteria F floatables N nutrients DO dissolved oxygen H hydrocarbons TP temperature T toxics S sediment	**MECHANISM**											
		SOURCE CONTROL							**TREATMENT CONTROL**				
		Managerial/ Operational	Good Housekeeping	Collection/ Conveyance	Containment	Reduction/ Elimination	Protection	Stabilization	Biological Treatment	Chemical Treatment	Filtration	Infiltration	Sedimentation
MARINA SITING AND DESIGN													
Marina Flushing	All	✓											
Water Quality Assessment	NA						✓						
Habitat Assessment	NA						✓						
SHORELINE STABILIZATION	S							✓					
Storm Water Controls	All	All											
SEWAGE CONTROL													
Sewage Facilities													
Dedicated Slipside System													
Portable System	B, N			✓	✓								
Sewage Facility Maintenance	B, N		✓										
WASTE MANAGEMENT													
Solid Waste	F		✓										
Fish Waste Composting Facility	B, N				✓				✓				
Liquid Materials			✓										
FUELING OPERATIONS													
Fueling Station	H		✓		✓								
Petroleum Management	H	✓	✓										
BOAT OPERATIONS													
Boat Cleaning	N, T				✓								
Boat Operation	H, N					✓							
Public Education	All	✓											

The *Bear River Fencing and Riparian Enhancement Project* is located in the southeast corner of Idaho in Bear Lake County. A stretch of Bear River has been subject to decades of improper grazing resulting in badly sloughed riverbanks and loss of riparian vegetation. Fencing and revegetation have allowed the riverbank to regain much of its original shape and function (left). The watering gap shown below is a simple solution that allows cattle to remain grazing in the area without destruction of miles of riverbank.

The *OX Ranch Agricultural BMP Implementation Project* was designed to improve water flows and fish habitat in the Lick Creek drainage. Located in west central Idaho, Lick Creek drains into the Wildhorse River, which in turn drains into the Snake River. All three drainages are listed as impaired water bodies. Irrigation water was diverted from Lick Creek and transported in ditches to the OX ranch to be used for irrigation. Prior to this project the NRCS estimated that water lost through ranch irrigation ditch banks was as high as 75%. In other words, only 25% of the water diverted from Lick Creek was actually being applied to the hundreds of acres of crop and pasture lands owned by the OX Ranch.

▶ *Water that used to be conveyed along a leaky irrigation ditch now is moved through a pipeline. This photo shows one of nine water tanks installed along the pipeline. The pipeline spans approximately 3.1 miles of open ditch. This project furnishes water to 145 acres of land and carries approximately 5.9 cubic feet per second of water.*

The pipeline spans approximately 3.1 miles of open ditch. This project furnishes water to 145 acres of land and carries approximately 5.9 cubic feet per second of water.

◂ *This portion of the pipeline is being used for irrigation. However, there are also livestock on this ranch that must be watered.*

▶ *This photo shows one of two stock ponds with overflow systems created along the 3.1-mile-long pipeline.*